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2008 : September 2008 - New Hot Papers : Xavier Obradors & Teresa Puig

NEW HOT PAPERS - 2008

September 2008

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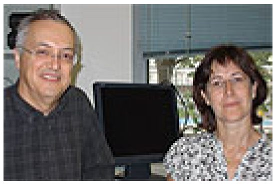
Xavier Obradors & Teresa Puig talk with *ScienceWatch.com* and answer a few questions about this month's New Hot Paper in the field of Materials Science.



Xavier Obradors & coauthor Teresa Puig

Article Title: Strong isotropic flux pinning in solution-derived YBa2Cu3O7-x nanocomposite superconductor films
Authors: Gutierrez, J;Llordes, A;Gazquez, J;Gibert, M;Roma, N;Ricart, S;Pomar, A;Sandiumenge, F;Mestres, N; **Puig, T;Obradors, X**
Journal: NAT MATER
Volume: 6
Issue: 5
Page: 367-373
Year: MAY 2007
* CSIC, Inst Ciencias Mat Barcelona, Campus UA Barcelona, Bellaterra 08193, Catalonia, Spain.
(addresses have been truncated)

SW: Why do you think your paper is highly cited?

The development of high-temperature superconductors (HTS) with high performances has been an outstanding problem of the physics and materials sciences over the past 20 years. For power applications of superconductors, the outstanding property is the critical current density, i.e., the total amount of current that you can transport without dissipation.

The achievement of high-critical current density is actually a nanotechnology issue, exactly the opposite than in semiconductor materials. A "good" superconductor is one which has an optimal concentration of non-superconducting defects or secondary phases, and these defects should have dimensions smaller than 10nm. But not all defects can be beneficial, for instance, grain boundaries could completely destroy their high performances.

Our work has described a new chemical methodology used to prepare nanocomposite superconductors, which fulfills all the stringent demands for a superconductor with high performance at high temperature under high magnetic fields.

The record performances achieved with these new materials have strongly stimulated further research in this area because their theoretical limit is still much higher and hence there remains room for improvement.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

Our paper has described a new methodology used to prepare epitaxial superconducting nanocomposites, which has resulted in new physical discoveries. One important hindrance of HTS is that they have a layered structure which results in anisotropic physical properties, particularly the critical current. This characteristic causes a lot of trouble for power devices design such as cables, magnets, or motors.

The materials that we have developed include randomly distributed and randomly oriented nanodots which deeply decrease the effective anisotropy of the superconducting $YBa_2Cu_3O_7$ matrix. This was an unexpected result which we have learned to quantify, but which still requires much more investigation, even if it has already raised a strong interest.

SW: **Would you summarize the significance of your paper in layman's terms?**

As we have mentioned a "good" superconductor is an "imperfect" material, about 10% of a non-superconducting phase should be mixed with the superconducting phase with its size in the nanometric scale; while it should, in addition, generate a massive density of nanodefects in the superconducting matrix. This segregation process should happen spontaneously in order to be able to produce conductors with kilometric lengths.

Three years ago, a collaboration between the University of Cambridge in the UK and Los Alamos National Laboratory in US (J. MacManus-Driscoll *et al., Nature Materials* 3: 439, 2004) showed that indeed this natural separation process occurs if you carefully select a material which can not mix up with the superconducting matrix.

This work was based on the use of a vacuum deposition method—"pulsed laser deposition" or PLD—while our work uses chemical solutions. The consequences of using this alternative methodology are straightforward because it turned out that the nanodots are growing in a different way, resulting in a different crystallographic orientation, and this has deep consequences within the physical properties. It is a good example to show that sometimes new methodologies open new avenues in the field of materials science.

SW: **How did you become involved in this research, and were there any problems along the way?**

We have been involved in the problem of understanding the mechanisms controlling critical currents in superconductors for about 20 years. It is a very complex physical problem involving vortex behavior—a collection of supercurrent whirlpools crossing the materials—and nanostructure generation.

During the past seven years, we have been the leader in EU projects. Two of these studies are: "Novel sol gel technology for long length superconducting coated tapes" or "SOLSULET," and "High-performance nanostructured coated conductors by chemical processing" or "HIPERCHEM," which is an effort to use a low-cost methodology in preparing the second generation of superconductors through "chemical solution deposition" or "CSD."

Our effort in understanding the materials science and physical properties has been essential to our achievement and this interdisciplinary approach has been essential. It is quite unusual to find physicists, chemists, and experts in microstructure working closely together. The achievement of our core group in Barcelona has been a key factor in our success.

SW: **Where do you see your research leading in the future?**

There is a still a long road ahead in this field. First, we need to understand more clearly the influence of the nanostructure on superconducting properties while also exploring new ideas about those physical mechanisms which pin vortices in superconductors. We are convinced that these performances can be deeply improved. We're also deeply involved in transferring our discoveries to practical conductors and this means gaining much more in reproducibility and strict control of those relevant parameters involved in the process.

SW: **Do you foresee any social or political implications for your research?**

High-temperature superconductivity is a key enabling technology for the development of efficient electrical energy delivery and management to society, and hence we are convinced that the impact of these materials in achieving a sustainable energy use will be very high.

The goal of our EU project HIPERCHEM is to develop low-cost fabrication methodologies and this is why we are closely cooperating with industry to make reality the development of conductors carrying 100 times more current than copper. Prototypes of cables, magnets, and "fault-current limiters" or "FCL," based on the new $YBa_2Cu_3O_7$ superconductors have already been demonstrated and we expect that its full engineering potential will be confirmed very soon.

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Keywords: high-temperature superconductors, high-critical current density, vortex behavior, nanotechnology, grain boundaries, non-superconducting defects, nanocomposite superconductors, power devices design, epitaxial superconducting nanocomposites, nanodefects in the superconducting matrix, pulsed laser deposition, nanodots, chemical solution deposition, fault-current limiters.

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